

ERGONOMIC ANALYSIS OF ELECTRIC AUTO RICKSHAW USING CATIA

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ABSTRACT

The aim of this research is to find the ergonomic risk related to Indian e-rickshaw and do the needed changes and improvements for the development of a new design of the e-rickshaw which ergonomically useful for its drivers. The ergonomic risk is calculated by analyzing the different postures gained by the drivers. The tool used for this purpose is RULA (Rapid Upper Limb Assessment). A RULA score of 5-6 indicates that the changes must be done instantly. So as to minimize the related ergonomic risk some modifications were suggested in the design of E-rickshaw. The scores of RULA computed after making said modifications in the model generated using CATIA showed that ergonomic risk is reduced considerably.

KEYWORDS: *Ergonomics, Rapid Upper Limb Assessment(RULA), Three Wheelers Ergonomics, Indian Anthropometry Data; E-Rickshaw, Three Wheeler Seat, Driver Seat Ergonomics & Posture Analysis*

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INTRODUCTION

It is known that India is a very big country with a population of 1.2 billion peoples, it is clear that public transport plays a crucial role in Indian economy. Most of the population being comprised of the poor and middle class which shows that public transport is the primary means of travel. The electric rickshaws are also falling under this category and becoming a most popular mode of transportation in India. Ergonomics is the study of the interaction between peoples and machines and the factors that affect the interaction. The term ergonomics comes from two Greek words- ERGO and ENORMOUS, which means “work” and “natural laws” respectively. Thus ergonomics means natural laws of working [1]. A survey was conducted to find the ergonomic risk among auto-rickshaw drivers; auto-rickshaw drivers remain seated in their seat for several hours and perform tasks that are dynamic in nature. The RULA score for this research came out to be 7 which means the condition of the job is very poor [2]. A survey was conducted to find out the various ergonomic risks for spool lifting, shifting and mounting activity in India plant and other developed countries. The RULA score for this survey comes out to be 4-5[3]. Electric auto rickshaws (also known as E-rickshaw) are becoming more popular since 2008 in the cities as an alternative to auto rickshaw and hand-pulled rickshaws. E-rickshaws are being accepted as an alternative to diesel/petrol/CNG auto rickshaws. These are the 3 wheelers which are pulled by an electric motor of 650-1400 watts. There are a few countries which manufactured these vehicles like India and China [5]. These vehicles have a mild steel tubular chassis; consist of 3 wheels with the differential mechanism at rear wheels. The body design is of very thin iron and aluminum sheets. These are 3 wheelers vehicles for hire which does not have doors included of a small cabin for the driver at the front and seats for a passenger at the rear. The driver not given so much consideration from the time it was first conceived in the 1990s. The design of this vehicle consists of a mall cabin

for the driver at the front and seats for passengers at the rear. The position of the handlebar and cabin is such that it bound the movement of the driver which leads to discomfort [4]. The space provided for the driver is so small that he is bound to a restricted area and cannot do his movements properly. E-rickshaw drivers have to maintain their position for several hours in a day which may cause musculoskeletal disorders among these drivers. The driver cannot move his legs properly while applying brakes because of the small space provided for the driver [8]. An open-labeled clinical study was conducted on auto rickshaw drivers to evaluate the stress over wrist joints of auto-rickshaw drivers [9]. A study was conducted on cycle rickshaw drivers enhance the design of cycle rickshaw. The changes made to design are an adjustable seat, a design of foot pedal, the introduction of a backrest. The results of this consideration are reduced the ingress and egress problems, reduces the efforts of the rickshaw puller, reduction of weight of the rickshaw [16]. Thus, the aim of this research paper is to find out the ergonomic risks that the e-rickshaw drivers are subjected to while driving and for evaluation, we have chosen the well-known ergonomic tools RULA (Rapid upper limb assessment)[17]. These methods was used by the researcher in the field of ergonomics to find out that a particular posture or process is disadvantageous ergonomically [10],[13]. In March 2015, the Indian parliament passed an amendment to the Motor Vehicles (Amendment Bill), 2015 legalizing E-rickshaw. By July 2015 Battery rickshaw are available for travel in many cities, now certified to ply with registration no. plate by R.T.O. with insurance. The CAD-3D model of the E-rickshaw is created in CATIA by using different designing tools.

Table 1.1: Level of Musculoskeletal Disorders Risks

Score	Level of MSD Risk
1-2	Negligible risk, no action required
3-4	Low risk, change may be needed
5-6	Medium risk, further investigation, change soon
6+	Very high risk, implement change now

The table1.1 shows the chances of musculoskeletal disorder risk with different scores. As shown in the table a score from 5-6 shows that there is medium risk and further investigation is needed. A score from 3-4 shows that there is low risk and changes may be needed. The score 1-2 shows that there is a negligible risk and no action is required. The score for the current model of the e-rickshaw is coming out to be 5 which mean there is the medium risk in this job and further investigation is needed. Thus this should be changed as soon possible. Therefore the aim of present work is to study the ergonomic risk associated with Indian E-Rickshaw drivers.

COMPUTATIONAL MODEL

The data used in this research paper is collected from observing different postures of an e-rickshaw driver. A 3D model of the e-rickshaw is designed in CATIA to carry out the ergonomic analysis. In order to find the risk associated with e-rickshaw drivers a well-known ergonomic tool, RULA is used for analysis purpose of e-rickshaw. In the present scenario, e-rickshaw drivers remain seated in their seats for long hours and perform tasks that are dynamic in nature. Therefore RULA was chosen because it is best suited for seated tasks. Thus RULA was used to evaluate the ergonomic risk associated with the working postures of E-rickshaw drivers. There were two main different postures attained by the e-rickshaw drivers. E-rickshaw drivers attain two different postures; one is the foot on the surface of the surface and second foot on the brake pedal as shown in figure 2.1.



Figure 2.1: E-Rickshaw Driving Posture

There was no use of backrest and the space provided for the driver is very small. This restricts the movements of the driver; a driver cannot make his legs movement properly when pressing the brake pedal.

For the analysis purpose, a 3D model of the e-rickshaw is designed in CATIA. All the parts of the e-rickshaw are designed in CATIA separately and then the assembly of these parts was done in catia. The dimensions of these parts are taken from the standard dimensions of e-rickshaw. The 3D model of e-rickshaw designed in the catia is shown in figure 2.1. As shown in the figure the seats are straight, padded benches and straight backrests for the driver and passengers. For the analysis, a manikin was inserted in the 3D model. This manikin is taken from the standard anthropometry data of the Indian population. The analysis is done for the 95 percentile of the total Indian population.

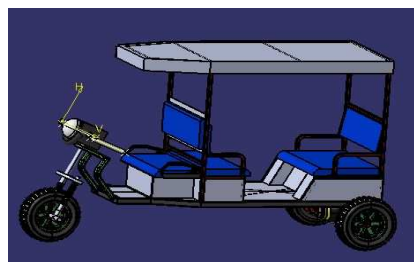


Figure2.2: Standard Model of E-Rickshaw in Catia

Figure 2.1 clearly shows that the backrest is not utilized properly by the driver. Hence there is room for improvement in the coordination between seats, backrest, pedals, and controls. The analysis for this model is done from both right sides and as well as from the left side of the driver. The results of the analysis are shown in figure 2.3. The final score of the analysis for the e-rickshaw standard model is 5, which means changes should be implemented immediately in the design. There is different score given to every part of the body and a final score is computed from these scores as shown in figure 2.3. For this standard model of e-rickshaw a score of 5 comes after doing the analysis which means there is a high risk of musculoskeletal disorders in this task.

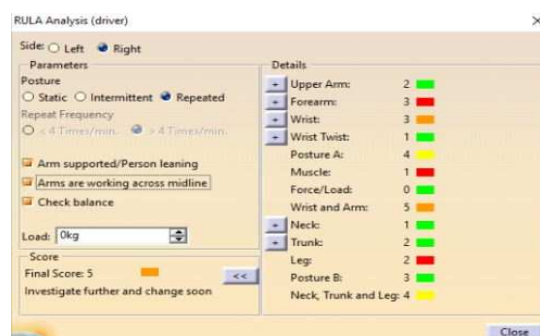


Figure 2.3: RULA Analysis Results for Standard Model

The analysis results are shown in figure 2.3 and it is clear from the score that the condition of the job is very

poor. The analysis score is 5 which means there is a high risk of developing musculoskeletal disorders and should be changed immediately. To minimize the ergonomic risk associated with e-rickshaw drivers two new models of seats are proposed.

RESULTS AND DISCUSSIONS

The RULA scores are computed for different postures attained by the e-rickshaw driver while applying brakes and when foot on the surface (as shown in figure 2.3). The scores for standard have been shown in figure 2.2. The RULA score for each position comes out to be 5 which propose that the ergonomic state of the job is poor and needed modifications should be done as soon as possible. Therefore needed modifications should be done in a small pan of time.

The possibility for enhancements in the present design can be approached from following two directions:

- Improvement in the design of the driver's seat.
- Improvement in the cabin space i.e. space provided for the driver.

Design of First Proposed Driver Seat

E-rickshaw seats are straight, padded benches with straight, padded backrest. This place is occupied by e-rickshaw drivers for several hours in a day. A newly designed e-rickshaw seat is shown in figure 3.1. The first proposed seat has the same dimensions as the standard model but the backrest of the seat is changed. The backrest angle is adjusted to 80 degrees and the height of the backrest is maintained at 600mm. A human manikin is inserted in this model. T human model is sitting on the driver seat, hands on the handlebar while the left foot is resting on the surface and right foot on the brake pedal shown in figure 3.1. The posture that has been found in Indian e-rickshaw drivers shown in figure 2.1 and it is clear from the figure that backrest cannot be utilized from this position. Hence there was an area for enhancement in the seat, cabin space, seat height, backrest tilt, seat tilt.



Figure 3.1: E-Rickshaw Model with First Proposed Seat

To enhance the posture of a driver the backrest must be flattened slightly. In order to provide support for the driver while backrest angle has been proposed to decrease 80 degrees. This will lead to increase the comfort level of the driver.

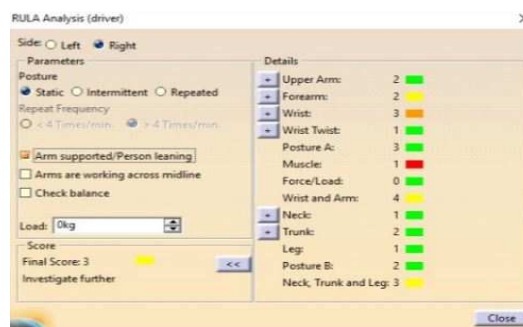


Figure 3.2: RULA Analysis Results for First Proposed Model

Design of the Second Proposed Driver Seat

The score for the first proposed seat is coming out to be 3 which mean there is low risk and changes may be needed. Thus to reduce the score a second model is proposed. The dimensions of the second model are shown in figure 3.4. The assembly of the e-rickshaw with second proposed seat shown in the figure 3.4 with a human manikin representing 95 percentile of the total Indian population. The analysis was done for both positions of the driver i.e. foot on brake pedal and foot on the surface of e-rickshaw.

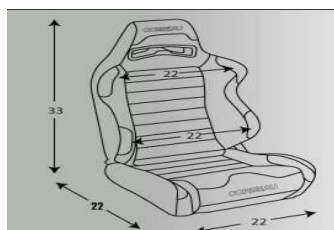


Figure 3.3: Second Proposed Model Dimensions (in Inches)

The assembly of e-rickshaw with a second proposed model of the driver seat is shown in the figure 3.4. As shown in the figure the new seat is comfortable for one person to sit at a time. An angle between seat and backrest is maintained at 80 degrees to provide the support for the back of the driver. As shown in the figure the new proposed seat is comfortable and allows the driver to do his movements easily.

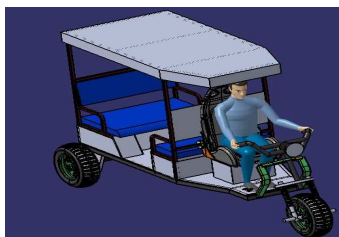


Figure 3.4: E-Rickshaw Model with Second Proposed Seat

Design of the Cabin

The space provided for the e-rickshaw driver is very small and restricts the movements of the driver to a small space. Thus restrict the movements of the driver's legs. This can lead to various musculoskeletal disorders and other injuries. This can lead to various musculoskeletal disorders like back pain, neck pain, Leg pain and trunk pain etc. In order to decrease the chances of musculoskeletal disorders, there is need of proper modification in the design of cabin space. The modification has been suggested to increase the space of the cabin. The driver's cabin length has been increased by

150mm in a forward direction. By increasing the length of the cabin the space of driver's cabin is increases and he can easily change his posture. After implementing the changes driver can easily do his movements and there is enough space for doing his legs movements.

After implementing the changes RULA analysis is done on the e-rickshaw model with the new seat. Different scores have been given to the various body parts. These scores have been given on the basis of the position of the body parts. The analysis score has been reduced from 5 to 2. The analysis score comes out to be 2 which show that there is a negligible risk and no changes were needed in the design. The analysis score with the new seat is shown in figure 3.5. It is clear from figure 3.6 that there was no change is needed in the design of the seat. The new design of the e-rickshaw is comfortable than the current e-rickshaw used in today. The comparison between old model and the newly designed model is given in table 3.1. The changes done in the seat and cabin length reduced the level of musculoskeletal disorders and provide the driver a better and comfortable ride. The RULA score reducing considerably in the new proposed model of the seat at different body parts like upper arm, forearm, wrist, neck, and trunk.

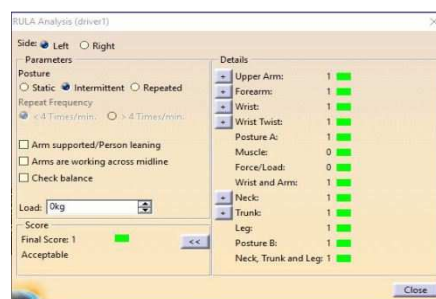


Figure 3.5: RULA Analysis Result for Second Proposed E-Rickshaw Model

Table 3.1: Comparison of Standard E-Rickshaw with New Proposed Model of E- Rickshaw

Body Parts	Standard Model Scores	First Proposed Model Scores	Second Proposed Model
Upper arm	2	2	1
Forearm	3	2	1
Wrist	3	3	1
Wrist twist	1	1	1
Posture A	4	3	1
Muscle	1	1	1
Force load	0	0	0
Wrist and arm	5	4	1
Neck	1	1	1
Trunk	2	2	1
Leg	2	1	1
Posture B	3	2	1
Neck, Trunkand leg	4	3	1
Final score	5	3	1

It is clearly shown in table 3.1 that analysis score is reduced from 5 to 1 which mean the chances of a musculoskeletal disorder is reduced. These suggested changes reduced the score of RULA analysis relatively as there is the significant decrease in the ergonomic risk involved in this proposed job.

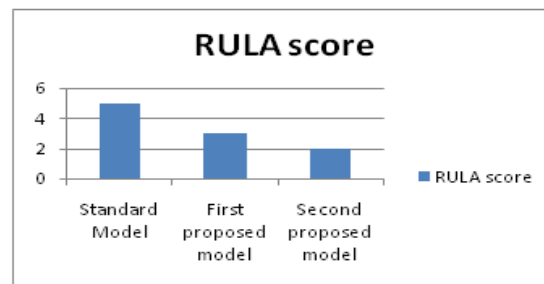


Figure 3.6: Comparison of Standard Model with New Proposed Models

The RULA score for the new proposed model was reduced considerably as compared to the standard model of e-rickshaw. Comparisons of the standard model with newly proposed models were shown in figure 3.6. As shown in the figure the RULA score was reduced considerably at upper arm, forearm wrist, neck and trunk for a new proposed model. The RULA score for the new proposed model has been reduced from 5 to 1 which shows that there is a negligible risk and changes may be needed. The RULA analysis score has been clearly shown that the score at different parts of body reduced considerably.

CONCLUSIONS

Prior to proposing the improvements in the design of e-rickshaw, a thorough study of the working postures of the drivers has been carried out using ergonomic assessment technique RULA. The final score of this method indicates that the e-rickshaw drivers have a high risk of developing musculoskeletal disorders and hence the working position should be modified instantly. In the current study, an attempt has been made to lower the ergonomic risks by proposing modifications in the design of the driver seat and cabin length. Two different seat models were proposed and the RULA analysis was done on them. Slight changes have been made in the dimensions of the driver's seat by considering anthropometrics of the 95th percentile of the total Indian male population. These changes will allow the driver to attain a comfortable and convenient position while driving. Secondly, some modifications have been made in the dimensions of the cabin which allow the driver to adjust his posture easily and also allow the driver to move his legs easily while driving. This is clear from the analysis results that the second seat model is best suited for an e-rickshaw driver. The advantages of the said modifications were clearly reflected in the scores that have been remarkably reduced. Hence there is a great scope for carrying out future research work in this field.

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